**We claim:**

1. A projection exposure apparatus comprising:

an illumination optical system including a light source for illuminating a patterning structure;

a projection optical system for projecting an image of the illuminated patterning structure onto a substrate;

the illumination optical system and the projection optical system each comprising a plurality of lenses;

wherein each of the lenses has a maximum design fluence value associated therewith, the maximum design fluence value representing a predetermined expected maximum fluence that the respective lens will be exposed to during a standard mode of operation of the projection exposure apparatus;

at least one lens being made of a lens material selected from a first group of lens materials wherein, after exposure to a given number of pulses of radiation of a given pulse length, each lens material of the first group has a characteristic transition point representative of a fluence value,

wherein each lens material of the first group will have rarefied after exposure to the given number of pulses of radiation of the given pulse length having any fluence value below its transition point, and wherein each lens material of the first group will have densified after exposure to the given number of pulses of radiation of the given pulse length having any fluence value above its transition point; and

wherein the transition point of each lens material of the first group satisfies the following condition:

$$T_{RC} < 0.8 \cdot H_D$$

wherein $T_{RC}$ represents the transition point of the respective lens material, $H_D$ represents the design fluence value of the respective lens, and

wherein at least one lens is made of a first fused silica material comprised in the first group of lens materials, wherein a transmittance of the first fused silica material obeys the relationship

$$T = 10^{-(k_o + k_{ind}) \cdot l}$$

with

T denoting the transmittance,

$k_0$ being an absorption coefficient of the first fused silica material before exposure to light of a wavelength of 193.4 nm,

$k_0+k_{ind}$ being a total absorption coefficient after the first fused silica material has been exposed to 160 million pulses of radiation having a fluence of 5 mJ/cm² and a wavelength of 193.4 nm,

and l being a length of a path of light through the first fused silica material,

and wherein the following condition is fulfilled:

$$k_{ind} < 10^{-3}\ cm^{-1}.$$

2. The projection exposure apparatus according to claim 1, wherein

$$0.05 \cdot H_D < T_{RC} < 0.8 \cdot H_D.$$

3. The projection exposure apparatus according to claim 1, wherein

$$0.1 \cdot H_D < T_{RC} < 0.7 \cdot H_D.$$

4. The projection exposure apparatus according to claim 1, wherein

$$0.001 \text{ mJ/cm}^2 < H_D < 0.05 \text{ mJ/cm}^2.$$

5. The projection exposure apparatus according to claim 1, wherein at least those lenses are made of the first fused silica material comprised in the first group of lens materials that fulfil the following condition:

$$G_i < 0.8 \cdot G_D$$

wherein

$G_i$ is an axial thickness of the $i^{th}$ lens,

and $G_D$ is an average of all axial thickness of the lenses, wherein the axial thickness of each lens represents a thickness of the lens at a location on the optical axis.

6. The projection exposure apparatus according to claim 1, wherein at least those lenses are made of the first fused silica material comprised in the first group of lens materials that fulfil the following condition:

$$G_i > 1.2 \cdot G_D$$

wherein

$G_i$ is an axial thickness of the $i^{th}$ lens,

and $G_D$ is an average of all axial thickness of the lenses, wherein the axial thickness of each lens represents a thickness of the lens at a location on the optical axis.

7. The projection exposure apparatus according to claim 1, wherein at least those lenses are made of the first fused silica material comprised in the first group of lens materials that fulfil the following condition:

$$D_i < 0.7 \cdot D_{max}$$

wherein

$D_i$ is an effective diameter of the $i^{th}$ lens, and

$D_{max}$ is a maximum effective diameter of a lens in the projection exposure system.

8. The projection exposure apparatus according to claim 1, wherein more than 50% of the total number of lenses in at least one of the illumination optical system and the projection optical system are made of a lens material selected from the first group of lens materials.

9. The projection exposure apparatus according to claim 1, wherein more than 75% of the total number of lenses in at least one of the illumination optical system and the projection optical system are made of a lens material selected from the first group of lens materials.

10. The projection exposure apparatus according to claim 1, wherein more than 70% of the lenses of the projection optical system are made of the first fused silica material comprised in the first group of lens materials.

11. The projection exposure apparatus according to claim 1, wherein at least two lens materials selected from the first group of lens materials are fused silica materials.

12. The projection exposure apparatus according to claim 1, wherein at least one lens of the plurality of lenses is made of calcium fluoride.

13. The projection exposure apparatus according to claim 1, wherein the light source is adapted to emit light a substantial amount of which has a wavelength shorter than 200 nm.

14. The projection exposure apparatus according to claim 13, wherein the light source is an excimer laser.

15. The projection exposure apparatus according to claim 13, wherein the light source is an ArF laser.

16. The projection exposure apparatus according to claim 1, wherein the given number of pulses of radiation is 10 billion and the given pulse length is 25 ns.

17. Projection exposure apparatus comprising:

an illumination optical system including a light source for illuminating a patterning structure;

a projection optical system for projecting an image of the illuminated patterning structure onto a substrate;

the illumination optical system and the projection optical system each comprising a plurality of lenses;

wherein each location on a surface of each lens has a design fluence value associated therewith, the design fluence value representing a predetermined expected fluence that the respective location on the surface of the lens will be exposed to during a standard mode of operation of the projection exposure apparatus;

wherein each location on the surface of each lens has a design fluence gradient value associated therewith, the design fluence gradient value representing a predetermined expected change of the design fluence value per unit length;

and wherein each lens has a first location with a maximum design gradient product associated therewith, the maximum design gradient product representing a maximum product of the design fluence gradient value and the design fluence value at the location of the design fluence gradient value for the respective lens;

at least one lens being made of a lens material selected from a second group of lens materials wherein each lens of the second group has a characteristic transition point after exposure to a given number of pulses of radiation of a given pulse length,

wherein each lens material will have rarefied after exposure to the given number of pulses of radiation of

the given pulse length having any fluence value below the transition point, and wherein each lens material will densified after exposure to the given number of pulses of radiation of the given pulse length having any fluence value above the transition point;

wherein each lens material further has a characteristic minimum value associated therewith, the minimum value representing a fluence value causing the greatest extent of rarefaction in the lens material after exposure to the given number of pulses of radiation of the given pulse length,

and wherein the minimum value $H_{min}$ of each lens material of the second group satisfies the following condition:

$$H_{min} < H_{GHmax}$$

wherein $H_{GHmax}$ represents the design fluence value at the location with the maximum design gradient product, and $H_{min}$ represents the minimum value of the respective lens material, and

wherein at least one lens is made of a first fused silica material comprised in the second group of lens materials, wherein a transmittance of the first fused silica material obeys the relationship

$$T = 10^{-(k_o + k_{ind}) \cdot 1}$$

with

T denoting the transmittance,

$k_0$ being an absorption coefficient of the first fused silica material before exposure to light of a wavelength of 193.4 nm,

$k_0+k_{ind}$ being a total absorption coefficient after the first fused silica material has been exposed to 160 million pulses of radiation having a fluence of 5 mJ/cm² and a wavelength of 193.4 nm,

and l being a length of a path of light through the first fused silica material,

and wherein the following condition is fulfilled:

$$k_{ind} < 10^{-3}\ cm^{-1}.$$

18. The projection exposure apparatus according to claim 17, wherein the transition point of each lens material of the second group satisfies the following condition:

$$T_{RC} < H_{GHmax}$$

wherein $H_{GHmax}$ represents the design fluence value at the location with the maximum design gradient product, and $T_{RC}$ represents the transition point of the respective lens material.

19. The projection exposure apparatus according to claim 17, wherein the at least one lens is a lens in the projection optical system.

20. The projection exposure apparatus according to claim 17, wherein the projection optical system has a pupil plane, wherein the projection optical system has an optical axis at least in a region of the pupil plane, and

wherein the lens is located at a distance from the pupil plane along the optical axis and

wherein the distance is shorter than a free diameter of the lens.

21. The projection exposure apparatus according to claim 20, wherein the distance is shorter than half of the free diameter of the lens.

22. The projection exposure apparatus according to claim 17, wherein more than 50% of a total number of the plurality of lenses in at least one of the illumination optical system and the projection optical system are made of a lens material selected from the second group of lens materials.

23. The projection exposure apparatus according to claim 22, wherein more than 75% of the total number of lenses in at least one of the illumination optical system and the projection optical system are made of a lens material selected from the second group of lens materials.

24. The projection exposure apparatus according to claim 17, wherein more than 70% of the lenses in at least one of the illumination optical system and the projection optical system are made of the first fused silica material comprised in the second group of lens materials.

25. The projection exposure apparatus according to claim 17, wherein at least two lens materials selected from the second group of lens materials are fused silica materials.

26. The projection exposure apparatus according to claim 17, wherein at least one lens of the plurality of lenses is made of calcium fluoride.

27. The projection exposure apparatus according to claim 17, wherein the light source is adapted to emit light a substantial amount of which has a wavelength shorter than 200 nm.

28. The projection exposure apparatus according to claim 27, wherein the light source is an excimer laser.

29. The projection exposure apparatus according to claim 27, wherein the light source is an ArF laser.

30. The projection exposure apparatus according to claim 17, wherein the given number of pulses of radiation is 10 billion and the given pulse length is 25 ns.

31. A projection exposure apparatus comprising:

an illumination optical system including a light source for illuminating a patterning structure;

a projection optical system for projecting an image of the illuminated patterning structure onto a substrate;

the illumination optical system and the projection optical system each comprising a plurality of lenses;

wherein each of the lenses has a maximum design fluence value associated therewith, the maximum design fluence value representing a predetermined expected maximum fluence that the respective lens will be exposed to during a standard mode of operation of the projection exposure apparatus;

at least one lens being made of a lens material selected from a first group of lens materials wherein, after exposure to a given number of pulses of radiation of a given pulse length, each lens material of the first group has a characteristic transition point representative of a fluence value,

wherein each lens material of the first group will have rarefied after exposure to the given number of pulses of radiation of the given pulse length having any fluence value below its transition point, and wherein each lens material of the first group will have densified after exposure to the given number of pulses of radiation of the given pulse length having any fluence value above its transition point; and

wherein the transition point of each lens material of the first group satisfies the following condition:

$$T_{RC} < 0.8 \cdot H_D$$

wherein $T_{RC}$ represents the transition point of the respective lens material, $H_D$ represents the design fluence value of the respective lens, and

wherein at least one lens is made of a first fused silica material comprised in the first group of lens materials, which first fused silica material comprises a

fused silica material manufactured by depositing $SiO_2$-particles to form a porous soot body, followed by vitrification, which first fused silica material has a $H_2$-content of about $5 \cdot 10^{15}$ molecules/cm³ or more.

32. A projection exposure apparatus comprising:

an illumination optical system including a light source for illuminating a patterning structure;

a projection optical system for projecting an image of the illuminated patterning structure onto a substrate;

the illumination optical system and the projection optical system each comprising a plurality of lenses;

wherein each of the lenses has a maximum design fluence value associated therewith, the maximum design fluence value representing a predetermined expected maximum fluence that the respective lens will be exposed to during a standard mode of operation of the projection exposure apparatus;

at least one lens being made of a lens material selected from a first group of lens materials wherein, after exposure to a given number of pulses of radiation of a given pulse length, each lens material of the first group has a characteristic transition point representative of a fluence value,

wherein each lens material of the first group will have rarefied after exposure to the given number of pulses of radiation of the given pulse length having any fluence value below its transition point, and wherein each lens material of the first group will have densified after exposure to the given number of pulses of radiation of

the given pulse length having any fluence value above its transition point; and

wherein the transition point of each lens material of the first group satisfies the following condition:

$$T_{RC} < 0.8 \cdot H_D$$

wherein $T_{RC}$ represents the transition point of the respective lens material, $H_D$ represents the design fluence value of the respective lens, and

wherein at least one lens is made of a first fused silica material comprised in the first group of lens materials, which first fused silica material comprises a fused silica material manufactured by depositing $SiO_2$-particles to form a porous soot body, followed by vitrification, which first fused silica material has an OH-content of about 50 ppm by weight or less.

33. The projection exposure apparatus according to claim 32, wherein the first fused silica material has a $H_2$-content of about $10^{15}$ molecules/cm³ or more.

34. Projection exposure apparatus comprising:

an illumination optical system including a light source for illuminating a patterning structure;

a projection optical system for projecting an image of the illuminated patterning structure onto a substrate;

the illumination optical system and the projection optical system each comprising a plurality of lenses;

wherein each location on a surface of each lens has a design fluence value associated therewith, the design fluence value representing a predetermined expected

fluence that the respective location on the surface of the lens will be exposed to during a standard mode of operation of the projection exposure apparatus;

wherein each location on the surface of each lens has a design fluence gradient value associated therewith, the design fluence gradient value representing a predetermined expected change of the design fluence value per unit length;

and wherein each lens has a first location with a maximum design gradient product associated therewith, the maximum design gradient product representing a maximum product of the design fluence gradient value and the design fluence value at the location of the design fluence gradient value for the respective lens;

at least one lens being made of a lens material selected from a second group of lens materials wherein each lens of the second group has a characteristic transition point after exposure to a given number of pulses of radiation of a given pulse length,

wherein each lens material will have rarefied after exposure to the given number of pulses of radiation of the given pulse length having any fluence value below the transition point, and wherein each lens material will densified after exposure to the given number of pulses of radiation of the given pulse length having any fluence value above the transition point;

wherein each lens material further has a characteristic minimum value associated therewith, the minimum value representing a fluence value causing the greatest extent of rarefaction in the lens material after exposure to the given number of pulses of radiation of the given pulse length,

and wherein the minimum value $H_{min}$ of each lens material of the second group satisfies the following condition:

$$H_{min} < H_{GHmax}$$

wherein $H_{GHmax}$ represents the design fluence value at the location with the maximum design gradient product, and $H_{min}$ represents the minimum value of the respective lens material, and

wherein at least one lens is made of a first fused silica material comprised in the second group of lens materials, which first fused silica material comprises a fused silica material manufactured by depositing $SiO_2$-particles to form a porous soot body, followed by vitrification, which first fused silica material has a $H_2$-content of about $5 \cdot 10^{15}$ molecules/cm³ or more.

35. Projection exposure apparatus comprising:

an illumination optical system including a light source for illuminating a patterning structure;

a projection optical system for projecting an image of the illuminated patterning structure onto a substrate;

the illumination optical system and the projection optical system each comprising a plurality of lenses;

wherein each location on a surface of each lens has a design fluence value associated therewith, the design fluence value representing a predetermined expected fluence that the respective location on the surface of the lens will be exposed to during a standard mode of operation of the projection exposure apparatus;

wherein each location on the surface of each lens has a design fluence gradient value associated therewith, the design fluence gradient value representing a predetermined expected change of the design fluence value per unit length;

and wherein each lens has a second location with a maximum design gradient product associated therewith, the maximum design gradient product representing a maximum product of the design fluence gradient value and the design fluence value at the location of the design fluence gradient value for the respective lens;

at least one lens being made of a lens material selected from a second group of lens materials wherein each lens of the second group has a characteristic transition point after exposure to a given number of pulses of radiation of a given pulse length,

wherein each lens material will have rarefied after exposure to the given number of pulses of radiation of the given pulse length having any fluence value below the transition point, and wherein each lens material will densified after exposure to the given number of pulses of radiation of the given pulse length having any fluence value above the transition point;

wherein each lens material further has a characteristic minimum value associated therewith, the minimum value representing a fluence value causing the greatest extent of rarefaction in the lens material after exposure to the given number of pulses of radiation of the given pulse length,

and wherein the minimum value $H_{min}$ of each lens material of the second group satisfies the following condition:

$$H_{min} < H_{GHmax}$$

wherein $H_{GHmax}$ represents the design fluence value at the location with the maximum design gradient product, and $H_{min}$ represents the minimum value of the respective lens material, and

wherein at least one lens is made of a first fused silica material comprised in the second group of lens materials, which first fused silica material comprises a fused silica material manufactured by depositing $SiO_2$-particles to form a porous soot body, followed by vitrification, which first fused silica material has an OH-content of about 50 ppm by weight or less.

36. The projection exposure apparatus according to claim 35, wherein the first fused silica material has a $H_2$-content of about $10^{15}$ molecules/cm³ or more.

37. A projection exposure apparatus comprising:

an illumination optical system including a light source for illuminating a patterning structure;

a projection optical system for projecting an image of the illuminated patterning structure onto a substrate;

the illumination optical system and the projection optical system each comprising a plurality of lenses;

wherein each of the lenses has a maximum design fluence value associated therewith, the maximum design fluence value representing a predetermined expected maximum fluence that the respective lens will be exposed to during a standard mode of operation of the projection exposure apparatus;

wherein more than 50% of a total number of the plurality of lenses in at least one of the illumination optical system and the projection optical system are made of a lens material selected from a first group of lens materials wherein, after exposure to a given number of pulses of radiation of a given pulse length, each lens material of the first group has a characteristic transition point representative of a fluence value,

wherein each lens material of the first group will have rarefied after exposure to the given number of pulses of radiation of the given pulse length having any fluence value below its transition point, and wherein each lens material of the first group will have densified after exposure to the given number of pulses of radiation of the given pulse length having any fluence value above its transition point; and

wherein the transition point of each lens material of the first group satisfies the following condition:

$$T_{RC} < 0.8 \cdot H_D$$

wherein $T_{RC}$ represents the transition point of the respective lens material, $H_D$ represents the design fluence value of the respective lens.

38. Projection exposure apparatus comprising:

an illumination optical system including a light source for illuminating a patterning structure;

a projection optical system for projecting an image of the illuminated patterning structure onto a substrate;

the illumination optical system and the projection optical system each comprising a plurality of lenses;

wherein each location on a surface of each lens has a design fluence value associated therewith, the design fluence value representing a predetermined expected fluence that the respective location on the surface of the lens will be exposed to during a standard mode of operation of the projection exposure apparatus;

wherein each location on the surface of each lens has a design fluence gradient value associated therewith, the design fluence gradient value representing a predetermined expected change of the design fluence value per unit length;

and wherein each lens has a first location with a maximum design gradient product associated therewith, the maximum design gradient product representing a maximum product of the design fluence gradient value and

the design fluence value at the location of the design fluence gradient value for the respective lens;

wherein more than 50% of a total number of the plurality of lenses in at least one of the illumination optical system and the projection optical system are made of a lens material selected from a second group of lens materials wherein each lens of the second group has a characteristic transition point after exposure to a given number of pulses of radiation of a given pulse length,

wherein each lens material will have rarefied after exposure to the given number of pulses of radiation of the given pulse length having any fluence value below the transition point, and wherein each lens material will densified after exposure to the given number of pulses of radiation of the given pulse length having any fluence value above the transition point;

wherein each lens material further has a characteristic minimum value associated therewith, the minimum value representing a fluence value causing the greatest extent of rarefaction in the lens material after exposure to the given number of pulses of radiation of the given pulse length,

and wherein the minimum value $H_{min}$ of each lens material of the second group satisfies the following condition:

$$H_{min} < H_{GHmax}$$

wherein $H_{GHmax}$ represents the design fluence value at the location with the maximum design gradient product, and

$H_{min}$ represents the minimum value of the respective lens material.